Chapter 1

Introductory Chapter: Introduction to Transcranial Magnetic Stimulation in Neuropsychiatry

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1. Introduction

Transcranial magnetic stimulation (TMS) is a non-invasive neurostimulation (or neuromodulation) method. The principle of TMS is based on the Faraday's principle of electromagnetic induction. Around the primary coil, through which a time-varying current is flowing, a changing magnetic field is created, which is able to induce a secondary current in conductors (including human brain) within its reach. It was not until 1985 when Barker and his collaborators developed a device that could generate a magnetic field of sufficient intensity to depolarize cortical neurons. The generated magnetic field lasts approximately 100–300 ms, and its intensity usually ranges from 1.0 to 2.5 T. Secondary current induces depolarization or hyperpolarization of cortical neurons—only neurons up to 1.5–2.0 cm from the stimulation coil can be influenced directly, but deeper parts of the brain can be influenced via transsynaptic connections. TMS causes activation of neurons, metabolic, hemodynamic, and behavioral changes [1].

TMS pulses can be administered individually—single-pulse TMS, in pairs few milliseconds apart—paired-pulse TMS, or repeatedly in a sequence (called usually train) lasting from seconds to minutes—repetitive TMS (rTMS). The first two types are usually used for research or diagnostic purposes (e.g., to assess the physiology of the human motor system, including cortical excitability), rTMS is used in the treatment because it can modulate cortical excitability and connectivity by inducing long-term potentiation-like or long-term depression-like plastic changes outlasting the stimulation period [2, 3].

The main indication of rTMS is the treatment of major depressive disorder. This method was approved in this indication by the Food and Drug Administration (FDA) in 2008; the approval was obtained in the European Union, too. Meta-analyses confirm the efficacy of

high-frequency (usually 5–25 Hz) rTMS of the left dorsolateral prefrontal cortex (DLPFC), low-frequency (≤1 Hz) of the right DLPFC, or bilateral stimulation (combination of high-frequency and low-frequency stimulation) [4, 5]. Other indications of rTMS are more or less experimental. They include the treatment of schizophrenia—either auditory hallucinations (low-frequency rTMS of the temporoparietal cortex) or negative symptoms (high-frequency rTMS of the left DLPFC) [3]. Another promising indication is the treatment of substance addiction, especially nicotine addiction by the decrease of craving (high-frequency rTMS of the left DLPFC). Tinnitus is another experimental indication with some promising results as well as the treatment of the obsessive compulsive disorder (OCD). Some positive results were published in the treatment of posttraumatic stress disorder (high-frequency or low-frequency rTMS of the DLPFC). TMS seems to be effective also in algesiology—especially in the treatment of neuropathic pain (high-frequency rTMS of the contralateral M1 area) or maybe of complex regional pain syndrome type I. The list of possible indications of rTMS includes Parkinson's disease (high-frequency rTMS of the M1 area), epilepsy (low-frequency focal stimulation), postictal rehabilitation, cognitive disorders (mild cognitive impairment and Alzheimer's disease), attention deficit hyperactivity disorder (ADHD), borderline personality disorder, eating disorders (especially bulimia nervosa), and some others [1, 4].

The advantage of rTMS is its good tolerability and safety. An only absolute contraindication is a metallic object in close contact with the stimulation coil. Relative contraindications include personal history of epilepsy (high-frequency rTMS); various (vascular, traumatic, tumoral, infectious, or metabolic) lesion of the brain; administration of drugs that can lower seizure threshold (without anticonvulsant medication); sleep deprivation, alcohol addiction; implanted brain electrodes; pregnancy (but several case studies and case series of the safe administration of rTMS in pregnant women were published), and severe or recent heart disease [6, 7]. The most serious side effect is the induction of seizure. However, this risk is very low. Other side effects include pain at the stimulation site and headaches. They are more frequent than seizures but usually mild. As for mental side effects, several cases of shift into mania in patients with bipolar disorder were reported, and several times positive symptoms of schizophrenia occurred after the stimulation for negative symptoms [1].

This book describes several aspects of TMS in neuropsychiatry. Hopefully, it will help to enhance the knowledge of TMS and its role in this developing discipline.

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